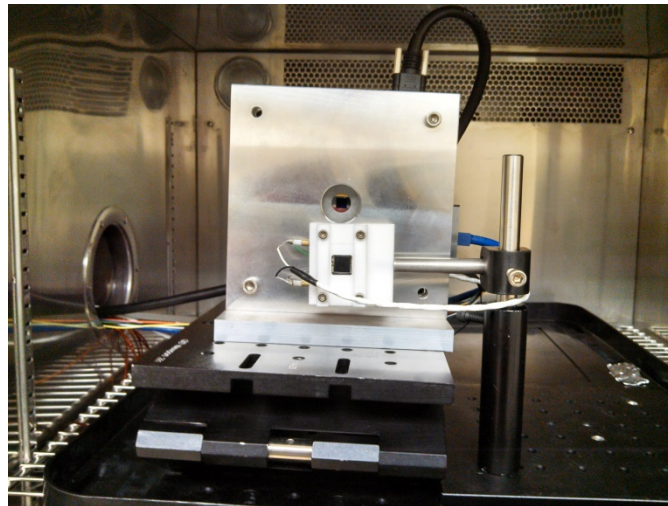
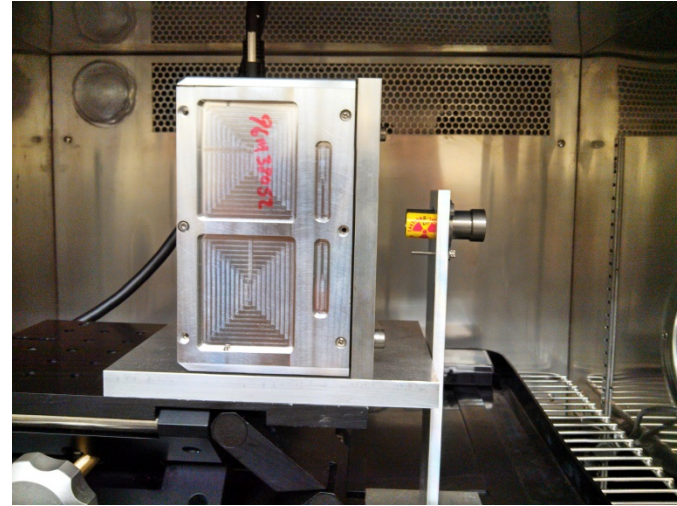
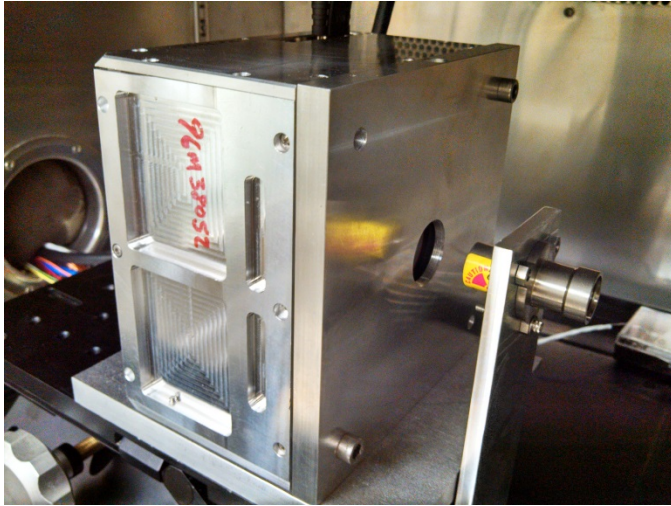


Performance Test of the CLASP Prototype Camera

Patrick Champey

Thermal Chamber Setup



Experimental Procedure

- Camera and Fe-55 source were placed in thermal chamber
- Visually aligned source with CCD aperture, source placed roughly 1 inch from detector
- Purged chamber with GN_2 for ~ 1 hour
- Took sample data set to confirm correct camera function, and source alignment
- Cooled the chamber down to ~ 1.7 C, recorded data set (1050 frames) at this temperature ($T_0 = 1.7$ C, $T_f = 3.9$ C)
- Recorded second data set (500 frames) at ~ 5 C ($T_0 = 5.05$ C, $T_f = 5.5$ C)

Image Calibration

- Removed every 1st, 2nd, and 3rd frame in each sub-set (50 frames/sub-set). These frames are not good for science because during long delays between exposures, charge from the DC offset builds up on the detector and saturates the device. It takes approximately 3 exposures (readouts) to clear the detector and registers.
- Generated a dark frame by taking the mean of all images at each pixel position. Pixels whose mean was outside $4 \times \text{sigma}$ of the mean background of all images were replaced with the mean background value.
- Generated a Bad Pixel Mask (BPM) by flagging any pixel position whose average intensity lies outside of the $4 \times \text{sigma}$ threshold. The BPM was applied as a reference, rather than a mask: subject pixels were compared to BPM, if BPM pixel position returned a zero, subject pixel was ignored.

Identifying an “Event”

- An “event” is a source emitted particle interaction with the detector. These events are typically seen as 1, 4, 9, and 25 pixel clusters.
- Ideally, events should be recorded by a single pixel, however, CCD detectors are susceptible to charge spreading. Charge spreading is when a photon interacting with the detector generates an electron cloud with a diameter equal to, or greater than the diameter of the incident pixel.
- Charge spreading makes it difficult to recover true signal, so we limit our measurements to include only events that are encompassed by a single pixel. Criteria for defining a single pixel event are: the pixel is not flagged in the bad pixel mask, it has a large signal (above 450 DN), and the 24 neighboring pixels do not have a signal $>10\%$ of itself.
- Pixels that met the first two criteria, but were neighbored by any number of pixels with a signal $>10\%$ of itself were ignored.

Plotting & Fitting

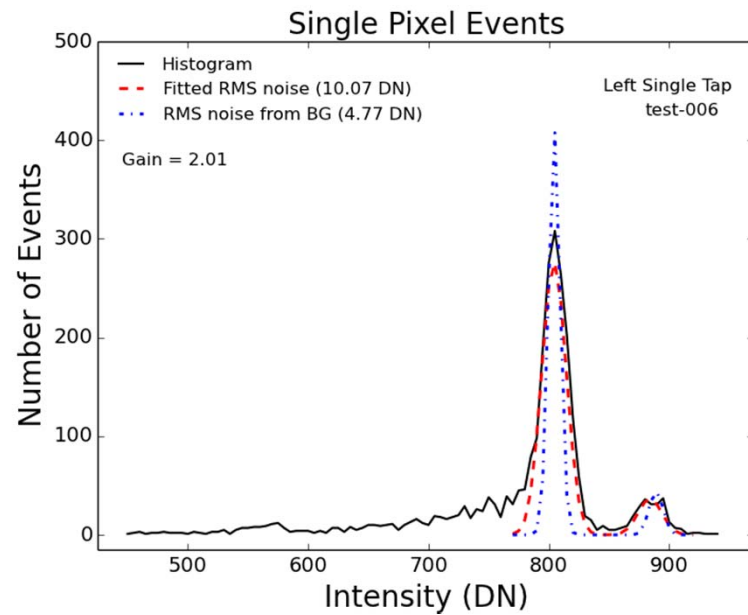
- The distribution of events as a function of DN represents the 4 discrete particle energies emitted from the Fe-55 source (5.89 keV, 5.90 keV, 6.49 keV, and 6.54 keV).
- Plotting the distribution of events, we expect 4 peaks; however, we only see 2. This is because charge spreading and Fano noise make the closely grouped energies unresolvable. There is too much noise for detector to distinguish 5.89 keV particles from 5.90 keV particles, and 6.49 keV particles from 6.54 keV particles.
- To fit the histogram, we use a quadruple Gaussian function. The function returns the amplitude (A_i) of each peak, along with gain and noise parameters.
 - Ex. $Y_i = A_i * \exp(-(x - DN_i/\gamma)^2 / 2 * \sigma^2)$, where γ = gain, σ = noise, DN_i = central DN of peak, and x = histogram bins

Plotting & Fitting

- The noise parameter in the fitting function returns the RMS of the camera noise, dark current shot noise, and Fano noise. The Fano noise depends on the energy of the incident photon and can be treated as a known value. Fano noise is subtracted from the calculated noise using the root difference square method, giving us camera noise and dark current shot noise.
- The camera readout noise determined by fitting a Gaussian to the distribution of background pixels from 2 Fe-55 images. The noise parameter from this Gaussian is the RMS of the camera noise and dark current shot noise (readout noise).
- Comparing the Fano subtracted noise from the fitting function with the readout noise determined from a Fe-55 image reveals a discrepancy in RMS readout noise. We think this may be the case because of charge spreading and is subject to further investigation.

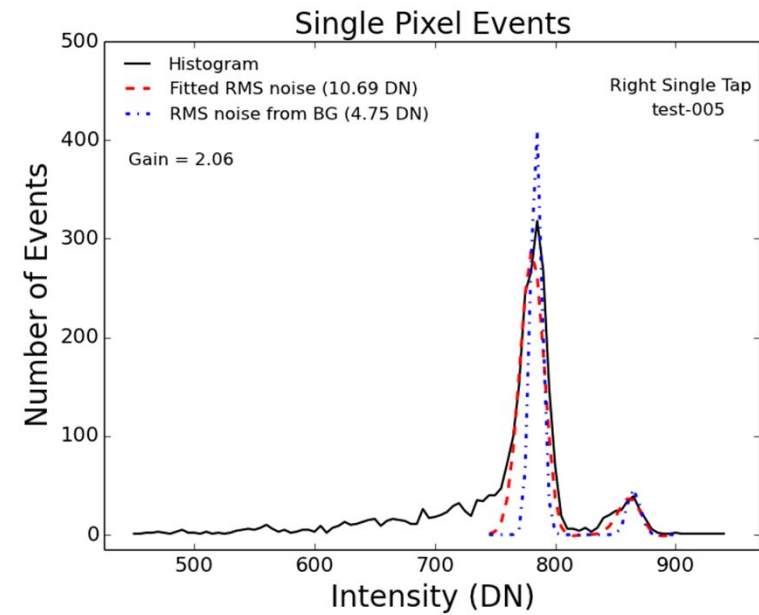
Gain - Left & Right Single Tap

Gain = 2.01



Left Single Tap

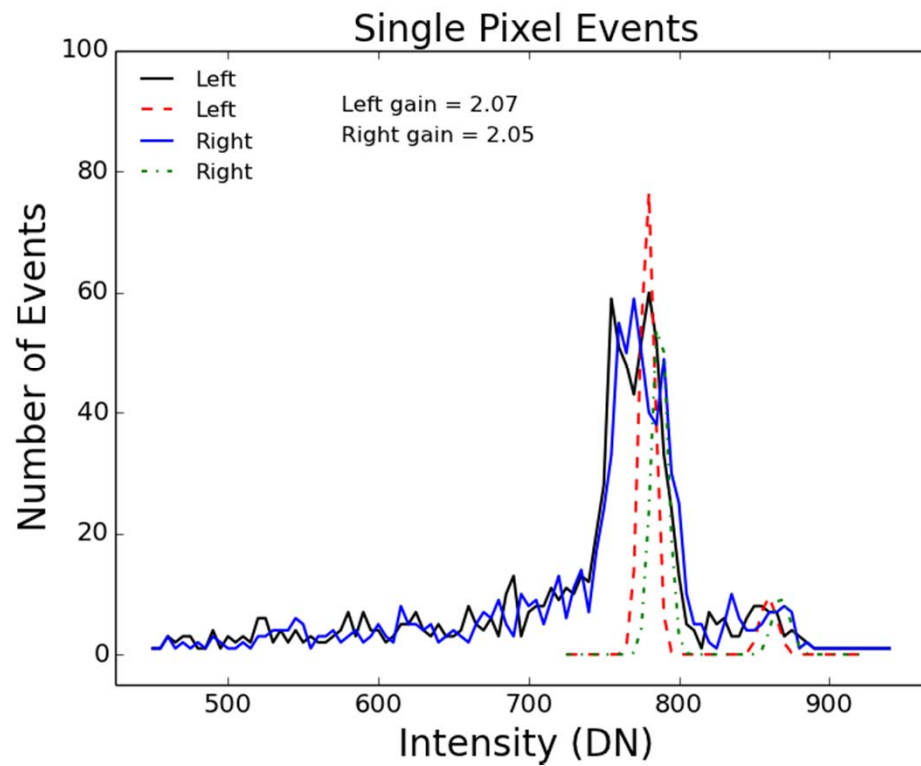
Gain = 2.06



Right Single Tap

Gain – Dual Tap

Left gain = 2.07 Right gain = 2.05



Dark Frames

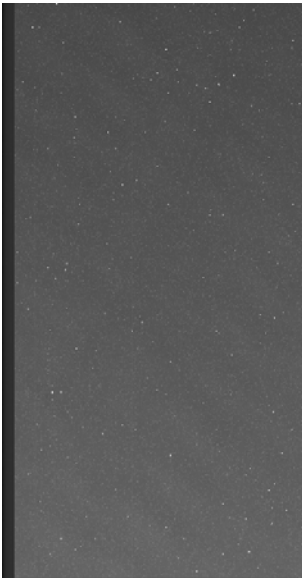
Mean Background

614 DN



Left Single Tap

Left = 621 DN



Right = 675 DN



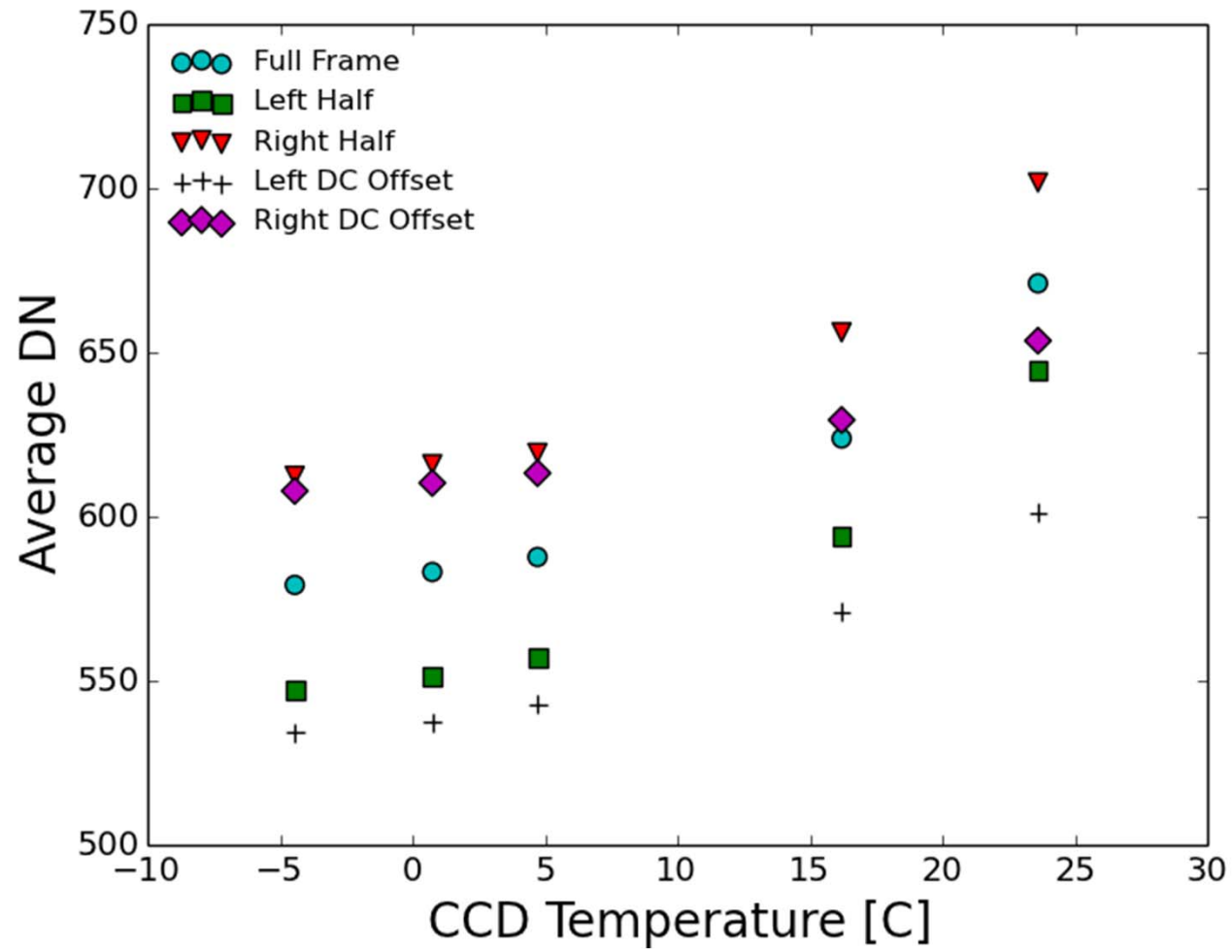
Dual Tap

658 DN

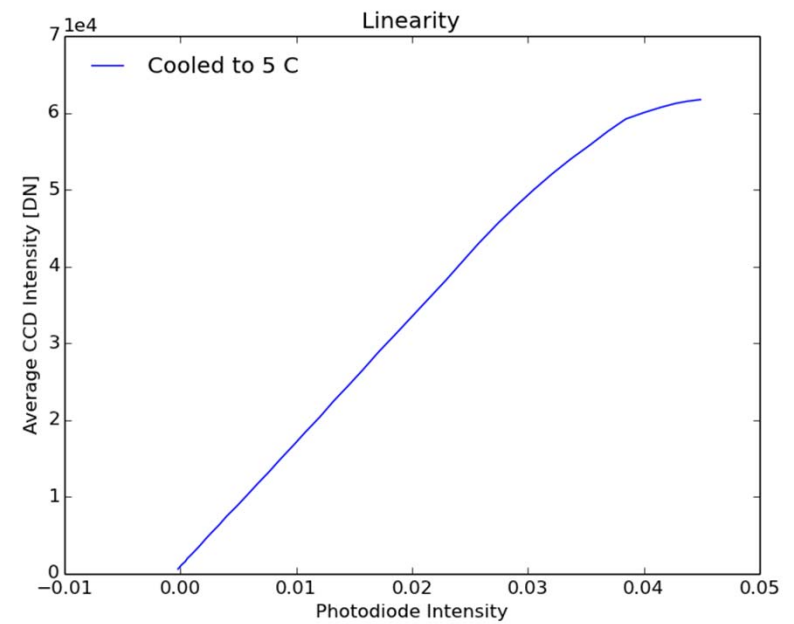
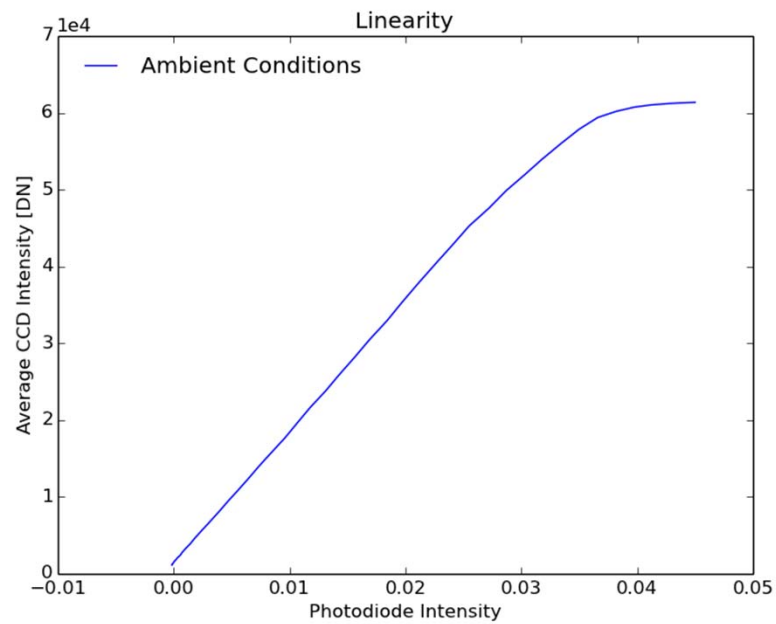


Right Single Tap

Average DN vs. Temp



Linearity



*Still need to do a linear regression

Things left to do

- Dark current vs. temperature fitting
- Linear regression on linearity plot
- Linearity for single tap modes